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Microbial and Biogeochemical Interactions at the Coastal Groundwater-Seawater Interface: The Role of Submarine Groundwater Discharge in Elemental Cycling

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Submarine groundwater discharge (SGD) is a key driver of nutrient fluxes into coastal waters, influencing primary productivity, microbial diversity, and elemental cycling. However, the role of groundwater-borne microorganisms in shaping microbial ecology at the coastal aquifer-seawater interface remains poorly understood. In this study, we integrate field observations, microbial community analyses, and biogeochemical measurements to assess the impact of SGD on microbial abundance, activity, and diversity in the East Mediterranean Sea.

Our results demonstrate that SGD introduces allochthonous microbial communities, which significantly alter the abundance of heterotrophic and autotrophic microbes in the receiving seawater. In controlled incubation experiments, filtered groundwater stimulated primary productivity, particularly Synechococcus growth, while non-filtered groundwater led to increased heterotrophic activity dominated by Rhodobacteraceae. These microbial shifts highlight competitive interactions between SGD-derived and native seawater communities, ultimately affecting carbon cycling and coastal food web dynamics.

Additionally, new data reveal a strong correlation between chlorophyll A concentrations and the travel time of saltwater within the coastal aquifer. Longer residence times correspond to higher nutrient transformation and organic matter remineralization. This suggests that groundwater transit times regulate the biogeochemical reactivity of SGD fluxes, impacting microbial metabolic pathways and nutrient availability.

By linking microbial ecology, SGD-driven nutrient fluxes, and hydrological controls, this study provides new insights into the integrated biogeochemical and microbial dynamics at the land-ocean interface. Understanding these interactions is critical for predicting coastal ecosystem responses to environmental changes, including sea-level rise and groundwater exploitation.